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THE INSTITUTION OF PRODUCTION ENGINEERS

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Contents:

"MODERN CAST IRONS"

by A. E. McRAE SMITH.

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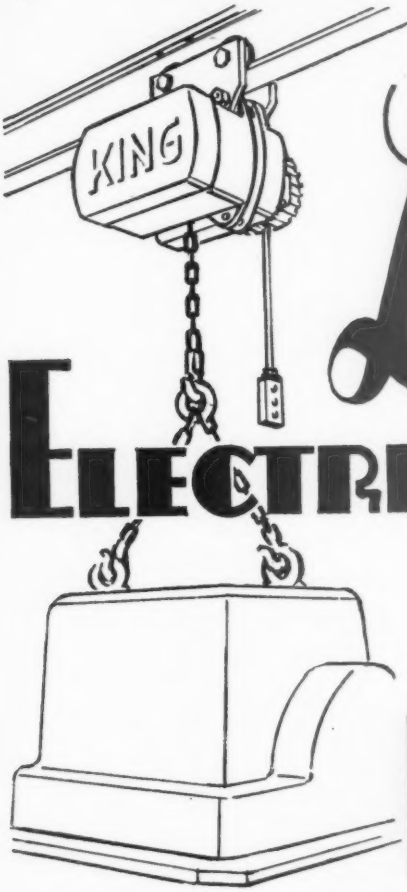

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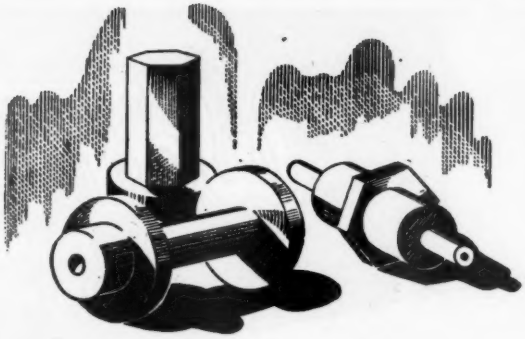

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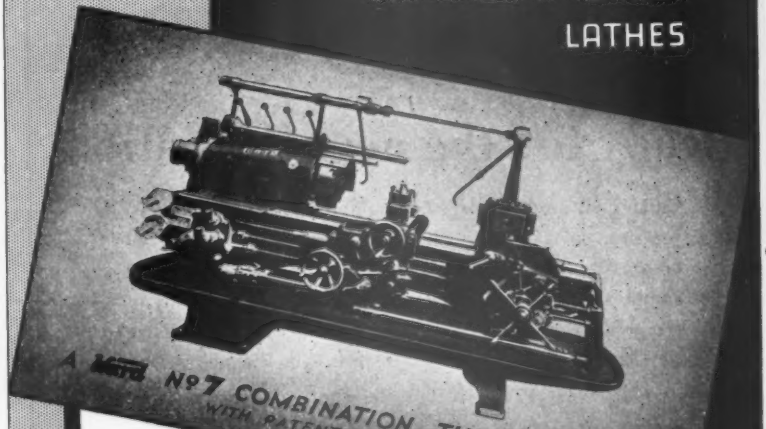

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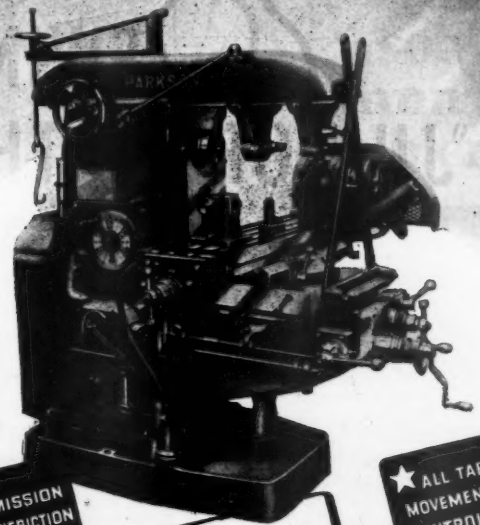

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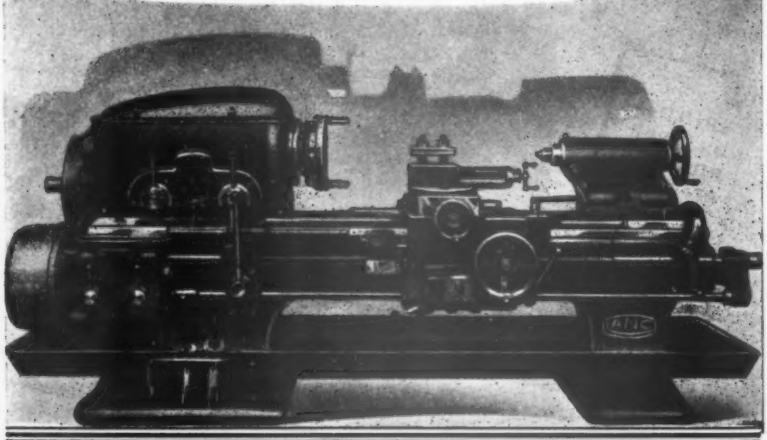

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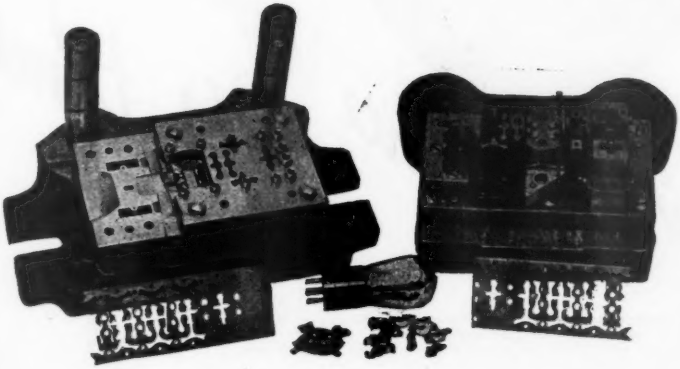

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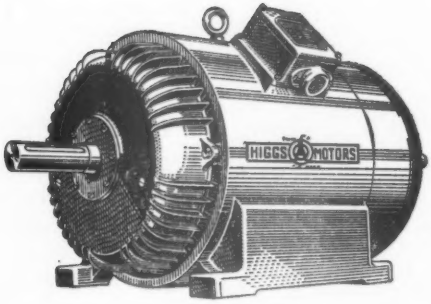

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INSTITUTION NOTES

August, 1946

August Meetings

10th Halifax Graduate Section. Works visit to the Butler Machine Tool Co. Ltd., Halifax, at 2-30 p.m.

SHREWSBURY SUB-SECTION. The June meeting took the form of a visit to the Prior's Lee Blast Furnace and Rolling Mill Plant of Messrs. Lilleshall Co. Ltd., on Saturday, 15th June.

This was the first visit to Works held by the Sub-Section and it proved highly successful. At the conclusion of the visit, an excellent tea was provided in the Works Canteen.

Letters of thanks have been sent to Mr. J. Willis Brown, Managing Director of Messrs. Lilleshall Co. Ltd., and to Mr. H. Hilton, the Works Manager.

Birthday Honours

Our sincere congratulations are extended to Mr. J. E. Blackshaw, M.I.P.E., Vice-President of Council, who appears in the list of Birthday Honours as the recipient of the M.B.E.

August Committee Meetings

— Finance and General Purposes Committee, at 2-30 p.m., in the TEMPORARY Committee Room, 36, Portman Square, London, W.1.

— Education Committee, at 10-30 a.m., at the Queen's Hotel, Birmingham.

— Membership Committee, at 12-30 p.m., at the Queen's Hotel, Birmingham.

Technical and Publications Committee meets every Wednesday at 5-30 p.m., in the TEMPORARY Committee Room, 36, Portman Square, London, W.1.

Until further notice, meetings of the Finance and General Purposes Committee, the Technical and Publications Committee, and the London Section Committee will be held in the TEMPORARY Committee Room at 36, Portman Square, London, W.1. All correspondence is still to be addressed to No. 10, Seymour Street, London, W.1.

Council Meeting

The next Meeting of Council will be held on Friday, October 4th, 1946, at 11.00 a.m., at the Institution of Civil Engineers, Great George Street, London, S.W.1.

Issue of Journal to New Members

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new members from the date they join the Institution.

Important

In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

Books Received

Workshop Technology, Part II, by W. A. J. Chapman,Ph. D., M.Sc. (Eng.), M.I.Mech.E., M.I.P.E. Published by Messrs. Edward Arnold & Co. Ltd., London. Price

Forming of Aluminium Alloys by the Rubber Die Press. Published by the Aluminium Development Association. Price 1s. net.

Combined Intelligence Objective Sub-Committee Reports

The following titles are additional to those published in the June Journal:

Survey of the German Can Industry During The Second World War. File No. XXX—85.

Visit to Mahle Kom. Ges. Pragstrasse, 26, Stuttgart, Bad Cannstadt (Metallurgy, Alloys). Final Report No. 238.

Visits in American and French Zones (Aircraft and Aircraft Engines). Final Report No. 170.

Magnetic Materials and Beryllium. Final Report No. 36.

Development of Ceramic Materials for use in Turbine Engines. File No. XXV—9.

German Airframe Tooling and Methods, Messerschmitt Works. File No. XXVIII—25.

Combined Intelligence Objectives Sub-Committee Reports—*Cont.*

German Aircraft Maintenance and Overhaul Methods. File No. XXVII—64.

The Electro-chemical Industry, Burghausen Area. File No. XXV—17.

Berlin Lubecker Maschinfabrik (BLM)—Artillery and Weapons. File No. XXXI—40.

Stuttgart Technische Hochschule (Fuels and Lubricants)—File No. XXXII—16.

Combination Air-Oil-Cooled Engine Development for 3-Ton Opel-Blitz Truck. File No. XXXII—60.

German Research and Development in the Radio Field, Lyons Area. File No. XI—7.

Wrought Light Alloy Plants in North-West Germany. Final Report No. 144.

Design of Mine-Diesel Locomotive. File No. XXX—43.

Robert Bosch G.M.B.H., Stuttgart (Aircraft Engines.) File No. XXXI—9.

Main Propulsion Steam Turbine Machinery of German Merchant Vessels. File No. XXXII—106.

Hermann Goering Steel Works, Paul Pleiger Hutte, Stahlwerke Braunschweig. File No. XXIX—30.

Research and Development in Hydraulic Couplings (Fluid Power Transmissions), J. M. Voith, Heidenheim-Brenz. File No. XXVII—13.

German Machinery Spring Industry. File No. XXVIII—15.

Manufacture of Steel Tubing by Hot Extrusion Mannesmann Rohrenwerke, Annen/Witten. File No. XXVII—88.

Some Aspects of German Work on High Temperature Materials. Final Report No. 272.

Investigation of Measuring Instruments, Gauges and Cutting Tools. Final Report No. 4.

Investigation of Honing Machines by Mayer and Schmidt A.G. At Offenbach. Final Report No. 5.

Telefunken Cathode Ray Tube Laboratories and Leuchtstoffe, Phosphor Manufacture. File No. XXXII—95.

Combined Intelligence Objectives Sub-Committee Reports—*Cont.*

Heat-Resisting and Corrosion-Resisting Alloy Steels. F. Krupp A.G., Essen. File No. XXXI—44.

Investigation of German Plastics Plants, Part 2. File No. XXXIII —23.

Cobaltine Alni-Steel Magnets. File No. XXXI—4.

German Tool and Special Steel Industry. File No. XXXI—26.

Manufacturing Process for Fabrication of Turbine Blades Used in 109-003 BMW Jet Propulsion Engine. File No. XXX—59.

German Facilities for the Production of Centrifugally Cast Gun Tubes. File No. XXIX—39.

The Design of German Aircraft Hydraulic Systems, Fuel Systems and Fuel System Components and Accessories. File No. XXXI—41.

German Gear Cutting Plant, Gear Manufacturing Technique and Design Development. Final Report No. 225.

Aluminium and Magnesium Production and Fabrication. File No. XXXII—59.

MODERN CAST IRONS

by A. E. McRAE SMITH, M.A.

Presented to the London Section, March 14th, 1946.

To give an address to the Institution of Production Engineers is a difficult task for a so-called foundryman, because in the past there has been a great lack of co-operation between the foundry industry, as producers of castings, and the engineering and allied industries, who purchase these castings. In the majority of cases this has been accidental and in no way reflects on either section, but it does show that there is a gap between the users of castings and their suppliers. When a foundry produces castings for the use of its own associated engineering works, difficulties of this kind do not normally arise. On the other hand, when castings are purchased in the open market, a great deal of misunderstanding may arise in regard to quality and requirements unless the castings are ordered to a definite specification, and rigid conditions of acceptance are agreed to and adhered to.

For this talk, the title " Modern Cast Irons " has been chosen deliberately because most of the published information on cast iron which may be of the greatest interest to users deals almost exclusively with high strength and special purpose cast irons, without any reference to the overall requirements of production engineers, who will have to handle common grey iron castings much more frequently than special iron castings. Therefore it may be advantageous to outline briefly the various types of cast iron which are commercially available today, so that production engineers may be given a broad outline of what it is possible to demand from any iron foundry in which they may be interested. Much trouble and many difficulties have arisen in the past because purchasers of castings have assumed that any foundry, irrespective of the scope of its plant, could supply castings suitable for any application.

Iron castings have from time to time been classified in a wide variety of ways, but generally speaking they can be divided into three main groups, namely :—

(1) Grey iron castings.
(2) White iron castings.
(3) Malleable iron castings.

It is not intended in this short survey to deal with malleable iron castings because that relates to a branch of the industry which would require at least a whole evening for consideration if it is to be treated adequately. Production engineers are likely to be most interested in grey iron castings and special types of castings related

thereto, so it may be best to describe the types available, their properties and applications.

Grey iron castings, in their turn, have also been sub-divided into a number of groups, and in order to grasp readily the potentialities of that material commonly known as "cast iron," it may be of some interest to survey these types.

Two classifications are generally recognized. The first divides the various classes of iron castings according to their structure, and the main classes are: (1) Ferritic (or soft and weak types); (2) Pearlitic (or medium strength grades); (3) Martensitic (both grey and white or hard cast irons not machinable by ordinary tooling methods); and (4) Austenitic cast irons (with a matrix broadly similar to stainless and non-magnetic steels but differing from them in the sense that they are true graphitic cast irons).

The second method of classification depends on mechanical properties as laid down by the B.S. Specifications for cast iron, namely B.S.S. 321 and B.S.S. 786, covering ordinary grey cast iron and high duty cast iron respectively. Unfortunately this classification does not cover any of the special cast irons used for applications where resistance to heat, abrasion, corrosion and other special properties are the main consideration, nor does it cater for austenitic cast irons.

Most likely it will be of more interest to production engineers to describe briefly the various types of cast iron available today, according to their main applications and the industries for which they are generally most suitable.

When we talk of modern cast irons, we must not forget that probably 90 per cent. of the requirements are for ordinary common cast irons with comparatively low mechanical properties. For the type of cast iron used today, as in the past, for all applications where a readily castable material, easily cast accurately to shape and with free machining qualities, is required, it is hardly necessary to refer to B.S.S. formulae. The two lowest grades of cast iron in the British Standard Specifications—B.S.S. 321, Grades C and A—are required to have a minimum tensile strength of 9 and 11 tons per square inch respectively, as measured on test bars with a cast size of 1·2 in. diameter. Obviously it is very difficult for any foundry to make a cast iron with mechanical properties less than either of the specifications. Therefore, for such types of cast iron, mechanical specifications are really unnecessary. From the production engineer's aspect, it is much more important that he should demand good machining properties and dimensionally accurate castings.

On the other hand, it must not be assumed that soft grey iron castings of this type do not serve a useful purpose. The whole of the light castings trade, including the textile, electrical, stove plate, radiator and rain water goods industries, have been built up on the

use of castings made in this type of cast iron. In almost every case the grade of cast iron used for such castings is of the phosphoric type, with phosphorus contents between 0·7 and 1·4 per cent., and made from native pig iron of which Derbyshire iron is a good example. Castings made in this type of high phosphorus cast iron are normally rather brittle, and therefore for certain engineering applications, even where the sectional thickness of the castings is extremely thin, it may be necessary to use a higher quality, but not necessarily higher strength type of cast iron, in order to avoid excessive brittleness.

This leads us to the conclusion that, from the production engineer's point of view, B.S. Specifications for cast iron are rather inadequate, even in the lowest grades. If it is desired to obtain a readily machinable but tougher type of cast iron for light section castings where tensile strength is really immaterial, then one must qualify the requirements and specify compositional limits, as well as the mechanical properties laid down in the B.S. Specifications. One can visualize applications, *e.g.* thin section castings as used for motor cycle engine cylinders, small size air and refrigeration compressors, and similar components, where a high phosphorus and comparatively brittle cast iron would be unsuitable, and yet where it is not necessary to have mechanical properties in excess of the requirements of B.S.S. 321, Grade A. Therefore production engineers should safeguard themselves when such conditions arise, by specifying composition as well as physical properties, in spite of the fact that in most B.S. Specifications for cast iron, mechanical properties only are considered.

Cast irons for general engineering purposes generally fall into the category supposed to be covered by the lowest grade of the high duty cast iron specification, B.S.S. 786, Grade I, calling for a minimum tensile strength of 14 tons per square inch on test bars cast 1·2 in. diameter. Actually it is rather ridiculous to consider seriously this grade of cast iron as being something very special if the mechanical properties are the only qualities which are to be taken into consideration. For all practical purposes, cast irons should not be considered to be in the high duty or high strength class unless they exhibit a minimum tensile strength of 20 tons per square inch on 1·2 in. diameter test bars. This is equivalent to the minimum requirements of B.S.S. 786, Grade 3. The intermediate grade, B.S.S. 786, Grade 2, calls for a minimum tensile strength of 17 tons per square inch on 1·2 in. diameter test bars, the size which may be taken as representative of most medium engineering castings.

As was explained when briefly dealing with castings related to the so-called "light castings trade," for important engineering castings specified to conform to B.S.S. 786, Grades I and II, it may always be necessary for the production engineer to specify limits of composition for high grade castings, even if only moderate mechanical

properties are required. This is particularly the case where pressure tightness to gases and liquids is essential. Phosphoric cast irons with, say 0·7 to 1·2 per cent. phosphorus, can be readily produced to possess mechanical properties in excess of the requirements of B.S.S. 786, Grade I, and in some cases Grade II, but castings made from such material are very prone to liquid shrinkage defects and unsoundness. Therefore it is desirable to place a limit on the phosphorus content, even if a full compositional specification is not demanded.

For most engineering applications, castings with mechanical properties up to the standard of B.S.S. 786, Grade II (*i.e.* with minimum tensile strength of 17 tons per square inch on 1·2 in. diameter test bars) will fill the bill, but there are quite a number of duties where the composition and structure of the cast iron is much more important than the mechanical properties, provided these exceed the predetermined minimum.

However, before proceeding it will be best to deal with the really high strength cast irons which have been developed in recent years and the higher grades developed during the war years. Prior to May, 1941, the highest grade of cast iron specified in British Specifications was B.S.S. 786, Grade III, calling for a minimum tensile strength of 20 tons per square inch on 1·2 in. diameter test bars. Castings required to meet this specification were usually made in some grade of alloyed and processed or silicon inoculated cast iron, such as Ni-Tensyl iron or Grade G.A. Meehanite cast iron.

In order to meet war-time requirements, and particularly where a high strength casting could be used to replace or substitute a steel component where rigidity coupled with high strength was more important than ductility, it was found desirable to specify cast irons with higher mechanical properties. Consequently, in May, 1941, a higher grade was added to B.S.S. 786, namely, Grade IV, required to have a minimum tensile strength of 23 tons per square inch on 1·2 in. diameter test bars. This grade was usually obtained by using processed cast irons containing nickel and/or molybdenum, *e.g.* molybdenum Ni-Tensyl iron and Meehanite cast iron, Grade G.M.

It was soon found that cast irons with even higher strengths and coupled with superior resistance to shock in a relatively non-ductile material, were necessary to meet some special requirements, *e.g.* shell and bomb forging dies, crankshafts for medium speed petrol and diesel engines, press dies, as well as highly stressed engineering castings. To meet these requirements a new type of nickel molybdenum cast iron, which originated in the U.S.A., was developed in this country by the Mond Nickel Company (British Patent No. 548102). It is known as acicular cast iron. This is essentially a nickel molybdenum cast iron made by a special process and it is characterized by a type of structure not usually met with previously

in commercially produced cast irons. Acicular cast irons have exceptionally good mechanical properties and usually give a tensile strength of 26 to 35 tons per square inch, irrespective of sectional size or mass. Their resistance to shock is also very good, being at least twice that of the highest strength types of pearlitic cast iron.

All the cast irons mentioned so far are general purpose materials, their application largely depending on the mechanical properties which they possess, but there are also a very large number of special types of cast iron which are finding extensive uses and which are not covered in any way by British Standard Specifications. To deal with these briefly, it will be most convenient to group them roughly according to their uses. The most important types are as follows :—

1. Abrasion-Resisting Cast Iron

In the grey cast iron category, the low nickel chromium cast irons find a wide field of application for such components as automobile cylinder blocks, diesel engine cylinders, liners, pistons, brake drums, machine tool parts, etc. These usually contain 1 to 2·5 per cent. nickel with 0·3 to 1 per cent. chromium added to a grey cast iron of carefully controlled composition. They are readily machinable but yet have much better wearing qualities than unalloyed cast iron on account of the beneficial effect produced on the matrix of the cast iron by carefully balanced additions of nickel and chromium.

Even more noteworthy for resistance to abrasion is the martensitic type of nickel chromium cast iron, known as Ni-Hard, containing 4·5 per cent. nickel and 1·5 to 2 per cent. chromium. This is a white cast iron which is much harder and tougher than ordinary chilled white iron. It is used very extensively for chilled rolls, ball mill liner plates, grinding balls, tyres for edge runner mills, shot blast nozzles, wheelabrator blades, and scores of applications where resistance to abrasion is essential. This material cannot be machined by ordinary tooling methods and must be finished by grinding. It is possible, however, to cast grey iron or mild steel inserts into the Ni-Hard castings, where machining operations such as boring, drilling or tapping must be carried out. Typical examples of the use of such inserts are seen in the production of impellors and liner plates for dredge pumps, conveyor rollers, etc.

Intermediate between these types of wear-resisting cast iron, we have the grey martensitic group, with 3·5 to 5 per cent. nickel, according to the mass of the casting. This material can be softened for machining purposes and rehardened by a simple heat treatment.

2. Heat-Resisting Cast Irons

In the low alloy group of heat-resisting cast irons much use is made of high graphite types made from a Hematite pig iron base

and with additions of nickel and chromium and/or molybdenum. High graphite cast irons show the best resistance to crazy cracking and heat checking, but they are inevitably weak and exhibit open grained structures. Suitable alloy additions render these structures close grained and also improve the heat-resistance of the matrix, and compensate for the reduction in strength brought about by the high graphite content. Typical applications are dies or moulds for gravity die castings, water cooled rollers for sheet glass production, various types of strip, billet and bar moulds for casting non-ferrous alloys, etc.

Among the higher alloy cast irons, the 33 per cent. chromium type is now widely used for heat-resisting applications, such as special fire bars, furnace grids, etc. Provided the carbon content does not exceed 1·5 per cent., this type of cast iron is quite machinable, but so far it has not been used for really large castings on account of the very limited sources of supply and restrictions caused by lack of suitable melting capacity in foundries handling this type of cast iron.

Some of the austenitic cast irons are also used for their heat-resisting properties, but strictly speaking, like austenitic stainless steels, cast iron of the Ni-Resist type should be classified as corrosion resisting material. Nicrosilal, with 18 to 20 per cent. nickel and 5 to 6 per cent. silicon, although an austenitic cast iron, is more often used for its heat-resisting properties. In the same way, Ni-Resist, particularly the type with chromium contents up to 5 per cent., is used for the same purpose.

3. Corrosion-Resisting Cast Irons

By far the most widely adopted type of austenitic cast iron is that known as Ni-Resist, containing 14 per cent. of nickel and upwards, coupled with 7 per cent. copper and 2 per cent. chromium. There are several different compositions used for different applications, but for general corrosion-resisting purposes, the alloy with 14 to 16 per cent. nickel and 6 to 7 per cent. copper and 1·5 to 2·5 per cent. chromium is most widely used in the chemical trade.

Where a copper-containing cast iron is undesirable, *e.g.* in food-handling equipment, copper-free Ni-Resist can be used containing 18 to 22 per cent. nickel.

Castings in Ni-Resist up to very large sizes are more readily available than other types of high alloy cast iron because it can be made successfully in the ordinary cupola furnace available in most iron foundries. Castings up to 5 tons in weight have been regularly produced. Ni-Resist is readily machinable, presenting no greater difficulties than would be expected in the handling of grey cast iron. It work-hardens, however, and therefore has good wear-resisting qualities, *e.g.* its use as liners for internal combustion engines. It

has a high co-efficient of expansion—approximately 50 per cent. greater than grey cast iron. For enhanced heat-resistance, as already mentioned, the chromium content may be increased to 5 per cent., but at this chromium level, it cannot be readily machined. Castings, however, may be easily finished by grinding.

4. Non-Magnetic Cast Iron

Ni-Resist cast iron is non-magnetic and is sometimes used for that reason but more often the type of austenitic cast iron known as Nomag is used. This contains 11 per cent. nickel and 6 per cent. manganese. It is extensively used in the electrical industry.

5. Acid-Resisting Cast Irons

Of the true acid-resisting cast irons, the only one worthy of mention is the high silicon type containing 12 to 14 per cent. silicon. It is extensively used for components of acid plant. It is very hard and brittle and can only be finished by grinding.

6. Low Expansion Cast Iron

Thirty-six per cent. nickel (Invar) type Ni-Resist is applied where the minimum expansion or dimensional stability is desired in iron castings. This has been used, particularly in U.S.A., in precision machine tool and instrument castings, where small temperature differences have caused errors in alignment of a few ten-thousandths of an inch in ordinary cast iron.

These special cast irons may not be of great interest to production engineers, but they must be included to make any survey of modern cast irons reasonably complete. Probably of more interest is the application of some of the lower alloy cast irons for specific purposes connected with process machinery. For example, extensive use is being made of low alloy cast irons for press dies. For cold working, the nickel chromium and pearlitic nickel molybdenum cast irons are being extensively and successfully used. For hot working dies, certain types of nickel chromium molybdenum cast iron have given outstanding performances.

Having described the types of cast iron available to the production engineer, his next problem will be to ascertain where all or any of these special types of iron castings can be obtained. The answer is that they should be obtained from specialist foundries, ot which there are quite a number widely distributed throughout this country. This is important, and the author would like to emphasize that it is useless to expect to obtain high strength and special alloy cast irons from the smaller jobbing foundries, who only produce common phosphoric grey iron castings.

It is also essential, when ordering special castings, that full details of requirements and specifications should be passed to the foundry at the time an enquiry is placed. Far too often, disputes arise because full details have not been passed to the supplying foundry.

Casting Design

Wherever possible, especially in the case of bulk orders for repetition castings, where new designs are involved, the production engineer should consult the supplying foundry. It is fully realized that iron foundries often blame design of castings for faults which have no relation to the shape or complexity of the casting, but there are also many cases where slight modifications might help the foundry, and consultations should be welcomed by both buyers and producers of castings.

Inspection and Quality of Castings

It is not intended to deal with the inspection of castings generally, but a few salient points might be emphasized. Even for quite small orders of castings, it is essential that accurate and suitable patterns are supplied. Engineers cannot expect to obtain good castings from poor and unsuitable patterns. In most cases, it is best to allow the foundry to make their own patterns and spread the cost over the first order. It should also be recognized that pattern tackle suitable for use in one foundry may not necessarily be adaptable for use in another foundry, due to divergence in production methods. This is particularly the case when dealing with large orders for repetition castings.

Apart from obvious defects, engineers should not accept misshapen or swollen castings. There is no excuse for any foundry supplying castings which are not reasonably accurate to drawing dimensions, provided good patterns are available.

Where repetition castings have to be jigged, the foundry should be consulted with regard to locating pads, etc. It is now possible to obtain certain castings, *e.g.* automobile cylinder blocks and cylinder heads, which have been accurately machined on the location pads or stripped before despatch. This ensures that castings will not be rejected at a later date during machining operations.

When dealing with large castings, foundries must be given reasonable tolerances in regard to overall dimensions, to allow for slight differences in linear contractions which inevitably arise. It is also unwise to be too niggardly with machining allowances on the top surfaces of really large castings, otherwise they may not clean up.

The real bugbear for the production engineer is the occurrence of one or two hard and unmachinable castings in a batch of otherwise perfect castings. Too often in the past the iron foundry

industry has taken the view that one or two hard castings in a large batch are unimportant, not realizing that an expensive tool setting may be ruined by the occurrence of only one hard casting. For light and medium castings, this danger can often be eliminated by the use of good quality low phosphorus cast iron made by one of the inoculation processes, because such cast irons are less prone to chilling, and the same basis composition can cover a much greater range of sectional sizes than would be the case with non-inoculated cast irons of the same composition.

In the case of many types of pressure tight castings, particularly cylindrical castings such as diesel engine liners, production engineers must be prepared to allow for the use of feeding heads which have to be removed by a machining operation. Grey cast iron cannot be readily cut by the oxy-acetylene torch, and therefore feeding heads cannot be easily removed, as is the case with steel castings. Yet in many cases, feeding heads are absolutely essential for the production of sound castings free from liquid shrinkage defects. This is a matter which must be discussed with the foundry at the time an order is placed for such castings.

The After-Treatment of Cast Iron

Various heat treatment processes can be applied to cast irons, the chief of which are as follows :—

(*a*) *Quenching and Tempering Cast Irons to give Improved Physical Properties*

As in the case of steels, the physical properties of cast irons can be modified by conventional quenching and tempering methods. Such treatments are usually applied to improve mechanical strength, hardness and wear-resistance. Pearlitic alloy cast irons, particularly nickel-containing cast irons, respond more readily to such treatment than is the case with ordinary grey cast irons, and the treatments can be of a less drastic character. For example, with nickel cast iron, oil quenching or, in some cases, air hardening, may be substituted for the water quench necessary to develop high hardness in plain cast iron. Nickel in cast iron acts in the same way as in alloy steels, increasing proportions of nickel enabling milder quenching conditions to be employed. In actual practice, the heat treatment of alloy cast irons by quench and temper methods is limited to comparatively simple shapes, such as liners, bushes, gear blanks, crankshafts, etc.

(*b*) *Heat Treatment to soften Castings and Improve Machinability*

Where it is desirable to promote the highest degree of machinability in soft grey cast iron, a full annealing treatment is given. This is largely practised in the textile machine trade. Pearlitic grey iron castings are fully annealed to render the matrix ferritic and

consequently softer. The mechanical properties of the cast iron are, of course, reduced after such a treatment.

In this connection, it should be noted that even after full annealing, cast irons rich in phosphorus cannot be rendered as soft as low phosphorus cast irons. This is due to the fact that the harder phosphide eutectic remains unchanged after full annealing.

(*c*) *Heat Treatment to relieve Internal Stresses or Stress Relieving*

Engineering castings, particularly those of complicated shape, are liable in time to show warping or distortion due to the gradual release of internal stresses set up during the time when the casting is solidifying and cooling down. This distortion leads to inaccuracy, especially in castings for precision machine tools, surface plates, jig and fixture castings, etc. It can also be a cause of trouble in piston castings and may lead to seizures due to pistons becoming oval. Castings of these types were very often "weathered" for very long periods before being machined, in an endeavour to release at least part of the internal stresses.

Stress relieving treatment is employed today to stabilize castings. It consists of a simple heat treatment cycle, thus eliminating the delay and inconvenience of "weathering" for long periods. The normal practice is to heat the castings slowly until a temperature of 450° to 500°C. is reached. They are then held at that temperature for approximately one hour, plus one hour for each additional one inch of thickness above one inch. After this the castings are slowly cooled.

It has been proved by a number of investigators that a temperature even as high as 500°C. does not relieve locked-up stresses completely, and to ensure complete freedom from stresses, temperatures up to 630° to 650°C. are necessary. Near that temperature range, namely, 650°C., structural changes begin to take place and it must not be exceeded. For most practical purposes, a temperature range of 450°C. to 500°C. will be sufficient, unless full stress relief is required.

(*d*) *Surface Hardening*, e.g. *Flame Hardening*

A type of treatment of special interest in machine tool and similar castings, consists in the surface hardening of faces subjected to wear, by means of flame hardening. In this process, the body of the casting is kept cool and the surface to be treated is rapidly heated locally to a temperature which will give a hard surface on quenching in water.

Nickel additions of the order of 1·5 to 2 per cent. are frequently made to cast irons which are to be treated in this manner, mainly because they respond better with more regular hardness and depth of hard layer, and also tend to reduce distortion. Quite recently

some attention has been given to flame treatment followed by air quench, which reduces distortion further. In order to obtain the desired hardness, say 450 to 500 B.H.N. by the air hardening methods, additions of 2 to 3 per cent. nickel are essential, the amount varying with the mass or self-quenching capacity of the casting being treated.

In conclusion, the above summary gives a brief survey of modern cast irons available to the production engineer today.

Research Department: Production Engineering Abstracts

(Prepared by the Research Department.)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract including the name and date of the periodical.*

COOLANT, LUBRICANT, FUEL.

Cutting Fluids, by William H. Oldacre. (*Mechanical Engineering, April,* 1946, *Vol.* 68, *No.* 4, *p.* 339, 8 *figs.*)

It is high time that the complexity of this subject is appreciated and the need for more accurate definition and classification of cutting fluids recognized. A consideration of the nature of cutting fluids follows. Turning to straight oil cutting fluids, the problem of description and classification is encountered. However, investigation discloses certain strongly evidenced truths: (*a*) the most obvious is that not all lubricating oils are good cutting fluids; (*b*) that there is some relationship between chemical activity and cutting-fluid performance; and (*c*) that more than one function may be involved in the lubricating process, especially under conditions of so-called boundary lubrication or those where metal-to-metal contact is involved. Developed for the investigation of gear lubricants, the five generally accepted machines all rate lubricants on the basis of seizure or scuffing of metal test parts in moving loaded contact. These machines are described. All tests on these machines point definitely to the function of sulphur, and certain sulphur compounds, as anti-weld agents. They also distinguish sharply between the functioning of sulphur and that of other additive compounds. Another interesting observation is the increased rates of "wear" with oils of high sulphur activity. Sulphur and sulphur compounds as anti-weld agents in cutting fluids are widely accepted and generally appreciated. However, it is not so clearly recognized that only a limited number of sulphur compounds are effective and these differ greatly in anti-weld efficiency. Improved correlation between laboratory and shop is imperative.

Cutting Fluids for Drilling. (*Production Engineering and Materials, February,* 1946, *Vol.* 17.)

The most suitable cutting fluids for various materials are listed in order of decreasing effectiveness and in order of increasing expense; also cutting compounds (solids) are listed separately.

(*Communicated by Industrial Diamond Review.*)

MACHINING, MACHINE TOOLS.

Conference on Machinability. (*Institution of Mechanical Engineers, 24th May,* 1946.)

The following papers were read:—

Group 1. Physical basis.

Machinability and Structure of Ferrous Materials, by Dr. C. Sykes.

The effect of variations in microstructure can be deduced in a qualitative

manner. For good machinability a combination of low hardness and low ductility is required ; such a combination may not be a satisfactory one for the subsequent application of the material. The relative distribution of ferrite and iron carbide is influenced by heat treatment, hot work, and composition ; by suitable manipulation of these it is possible to change the structure of the steel and thereby change the hardness and ductility. When the carbon content of steel exceeds 0·5 per cent. an improvement is effected by annealing the steel at temperatures just below 700°C. Steels containing more than 0·9 per cent. carbon consist of pearlite and excess carbide, which should be uniformly distributed as small particles. This structure can be obtained by suitable forging treatment, followed by annealing so as to bring about spheroidization.

It is possible to overdo the annealing ; the resultant product is soft, causing little wear on the cutting tool, but the machined surface is torn and rough. It is necessary, therefore, to arrive at a compromise between tool wear and surface finish, adjusting the annealing treatment to give good surface finish and reasonable tool life. Low-carbon steels cause difficulty owing to the high proportion of ferrite which gives continuous ductile chips. Cold working of such steels is an advantage, the improvement by the reduction in ductility outweighing any loss due to increased hardness. Additions which interfere with the continuity of the ferrite generally improve machinability, *e.g.* the graphite flakes in cast iron. With steels subject to much machining and not highly stressed in service, it is worth while to make additions which will form suitable inclusions. Substances added are sulphur, lead and selenium, but these may introduce disadvantages in other directions. Apart from discontinuities, improved machinability can be brought about by reducing the ductility of the ferrite, *e.g.* manganese, but the improvement is not very pronounced and if the additions are too great the increase in hardness is excessive. Phosphorus causes a comparatively large loss in ductility for a slight increase in hardness, but the reduction in ductility and impact properties discourage its use. The stainless and austenitic steels are generally difficult to work, as they are usually very ductile and have a high capacity for work-hardening and give rise to tough continuous chips which readily adhere to the point of the tool.

Free machining additions of sulphur, selenium, lead, etc., are made to improve machinability and give very satisfactory results. The very great improvements in such operations as sawing, drilling, etc., indicate that the machining difficulties of austenitic steels are to be attributed not so much to their work-hardening capacity as to difficulties associated with the rapid elimination of the chips from the working face of the tool.

Relation of Machinability to Structure—Non-Ferrous Metallurgy, by A. J. Murphy.

Quantitative data on the machining characteristics of non-ferrous metals and alloys are not plentiful, and there are few opportunities for correlating machining characteristics with structure. Crystal structure may be face-centred cubic, body-centred cubic or hexagonal close-packed. The outstandingly good machinability of the last in magnesium alloys is notable. Microstructure affects machinability, and hot working gives rise to a directional microstructure, and rod with this banded or "fibrous" microstructure is readily machined in operations involving cutting transversely. A classification in relation to machining characteristics which has been employed for copper alloys, and is capable of wider application, is based on the microstructure.

Group "A" is constituted of alloys having a one-phase microstructure ; "B" is of duplex or complex microstructure, and "C," the most interesting, contains the alloys in which special elements have been added to improve machinability, the basic structure being either homegeneous or duplex. The best known addition is lead in brass. It is generally considered that these particles of lead improve machinability either by weakening the resistance of the chip to

transverse shearing, or by reducing the friction between the chip and the face of the tool, but these suggestions are open to criticism, and a fuller understanding of the influence of lead requires information on the shearing deformation of leaded brass studied especially on a micro-scale.

Sulphur, selenium, and tellurium can be used in copper alloys, but it is difficult to retain sulphur in the required quantities. Among the common aluminium alloys, machinability generally improves as the hardness increases. The development of free-cutting wrought aluminium alloys has presented difficulties, but the problem has been attacked by the addition of other low melting point metals with lead, such as bismuth, or by antimony and tin. Free machining characteristics similar to those of leaded brass can be attained in wrought aluminium-magnesium alloys containing 7 to 9 per cent. magnesium, by making additions to produce suitable compounds with aluminium, *e.g.* chromium and manganese. A metallographic study of the mode of deformation in the vicinity of the particles in "free-cutting" non-ferrous alloys would greatly assist towards a correct appreciation of the significance of structural factors. This study should include an examination of the shearing process occurring at the elevated temperatures attained at the tool face.

The Mechanics of the Cutting Operation, by Prof. R. N. Arnold and G. A. Hankins.

A geometrical interpretation of cutting offers a reasonable picture of the cutting action. The authors believe that the mechanism of cutting is associated with the known characteristics of deformation and failure under load and in the tensile stress-strain diagram. The three main types of chip formation are (*a*) continuous chip, (*b*) continuous chip with "built-up edge," and (*c*) discontinuous chip. These are described and illustrated. A logical measure of the machining process is the work expended per unit volume of metal removed for which an expression is obtained, showing the connexion between the cutting operation and the properties of the metal, and the importance of the friction coefficient. The influence of the cutting conditions, the tool and vibration are indicated.

Group II. Testing Methods.

Testing Methods Using Pendulum Machines, by A. S. Kenneford.

The Oxford-Airey pendulum machine consists of a weighted pendulum, the shaft of which carries, on one side, a pointer moving over a scale graduated in degrees, and on the other a cutting tool. The height to which the pendulum rises when allowed to fall freely from the position of maximum potential energy is taken as the zero, and the height to which it rises after cutting the test piece gives a measure of the energy absorbed in cutting. In the Leysensetter double pendulum machine, a "standard" tool is fixed in a holder on the end of a pendulum and is allowed to swing through an arc of 15° on the surface of the material to be tested. The tool and holder are then fixed in a lathe and a standard cut is made. The tool and holder are then again transferred to the pendulum and released to fall through the same angle as before. The blunted tool will not cut as deeply as before and the back thrust is transmitted to the point of suspension of the pendulum. This suspension is carried at the end of a lever called the secondary pendulum, and the rise of this lever from its horizontal position is registered on a dial, thus giving a measure of the extent to which the tool has been blunted. Investigatory work with the Oxford-Airey type is described.

Notes on Machinability Testing Apparatus and Tests Carried Out at the Naval Ordnance Inspection Department, Sheffield, Including a Development of the Drill Test, by D. G. W. Curry.

Attempts were made to solve shell-machining difficulties by investigating machinability by drilling tests. The torque and thrust on a standard drill were measured for a range of materials, but no general relation to machinability during production could be deduced.

Standardization of Tools for Machinability Tests, by Lieut. C. H. Booth.

When new materials are introduced, experience has shown that results from a single test such as turning, drilling, or sawing will not satisfy the requirements for the other operations, and tests embodying all these are necessary if complete information is required. The information obtained should indicate the tool material, the cutting angles, the surface finish of the cutting edges, necessity for chipbreakers or special swarf removal, the speed of cutting and the area of the chip, the coolant to be used, and finally the life of the tool when cutting under these conditions. Practical precautions relating to the tool preparation and test control necessary to obtain satisfactory test results with single point tools, drills, taps and saws are described.

A Tentative Method of Assessment of Machinability, by C. W. George.

Two standard test pieces were evolved on which (*a*) turning, grinding, die threading, thread grinding, and thread rolling, and (*b*) milling, surface grinding, drilling, tapping, reaming and broaching can be carried out. In conjunction with standardized test charts, these operations are carried out in sequence to indicate the machining characteristics of the material being tested. The scheme has received some support from both material manufacturers and users, but it is appreciated that the proposed scheme has limited scope and is only intended to be an interim measure until such time as a reasonable quantitative method of assessing machinability has been developed for general use.

Tool Wear as a Measure of Machinability, by C. Eatough.

The degree of machinability of the material cut is reflected by tool life, and an attempt to deduce the machinability of materials by measuring the amount of wear on cutting tools of predetermined shape after operating under certain set conditions, was made. Tests were carried out on a lathe with a test tool and additional tools which undercut the main tool and eliminated end radius effects from the tests. Tool wear was measured by a Tomlinson surface finish recorder, and the results were expressed as the cross-sectional area of the crater measured after a standard life test had been run on the work material being examined.

Group III. Cutting Conditions and Their Effects.

The Effect of Speed, Feed, and Angle on Machinability, by W. Whitworth Taylor.

The recent work of Merchant on the mechanics of the metal cutting process are briefly reviewed. The conclusions are (1) that machinability is unaffected speed, feed, or angle but is a true constant of any given material to be cut; (2) the efficiency with which any given material may be cut is affected by variations in speed, feed, or angle, but the precise relationship of these has yet to be determined.

Tool Materials, by J. E. Attwood.

The tool engineer should strictly limit the number of suppliers and types of material. For medium-tensile steels, standard high speed steel (18—4—1) is recommended. For high-tensile steels of 70-80 tons, tungsten-cobalt high-speed tool steel is recommended, except for tapping or where the tool is subject to

shock. For aluminium alloys and other non-ferrous materials, carbide and diamond tools can be used. Tools of the cobalt, chromium tungsten type are excellent for heavy initial cuts from steel forgings. Carbide-tipped tools are best for long production runs, maximum tool life and high-class finish. Essential conditions for their use are: (*a*) Ample machine power; (*b*) Absence of vibration; (*c*) Uninterrupted cutting; (*d*) Diamond lapping of the tool after grinding; (*e*) Rigid tool support. General recommendations for machining are also given, reference being made to tapping, drilling, sub-zero treatment, war-time substitutes and butt welded tools.

Cutting Fluids, Chipbreakers, etc., by W. A. Carter.

The fluid most effective for a particular cutting operation cannot be properly decided upon without practical trials, and only approximate rules have so far been determined, though the general factors affecting coolants and the cutting action are indicated. Coolants are generally aqueous solutions or emulsions, their essential properties being due to their high water content. Lubricants are generally straight oils which will not form emulsions with water. Pressure-resisting lubricants are oils containing sulphur, chlorine, zinc, or other similarly reactive agents which, under high temperatures and pressures, will provide extremely thin films of metallic oxides or sulphides, etc., as a high-pressure lubricating medium between the chip and tool face. Important questions are whether to cool, to cool and lubricate, to lubricate with cooling effect, or to reduce adhesion between the chip and tool and effects on the job. The simplest and most favoured chipbreaker is a shallow step in the tool face at the cutting edge. Its function is explained and recommendations for its design are given.

Group IV. Machinability in Relation to Economy of Production.

Heavy Engineering, by G. M. Baker.

Values are given for the increase in machining cost over mild steel for a range of materials and for comparative rates of metal removal and power required. In heavy engineering materials are usually chosen for design reasons, and the production staff must accept them, but foreknowledge of machinability would be of great use for estimating costs and times.

Medium Engineering, by L. Johnstone.

Heavy cuts and large machined surfaces are avoided where possible, and machined surfaces are given a finish suited to their duty. Machinability has been widely considered in the past, and it is not often now that the material for established designs can be changed with economic advantage as shown by typical comparisons of changes to improve the machinability of particular parts. Good machinability in aluminium and magnesium alloys can be made use of and their field of application extended. Improved machinability in steel by sulphurizing and the addition of lead, etc., can be of economic value. Improved machinability by normalizing or annealing is essential with some steels.

Light Engineering, by P. C. Redwood.

With increased machinability higher rates of speed and feed can be employed, but swarf clearance and the grouping of operatives have to be considered. The saving effected in labour cost should not be over-estimated, as this charge seldom exceeds 10 per cent. of the ultimate selling price. Poor machinability is probably the most frequent cause of cutting tool failure and machine tool breakdown, and the savings in machine tools and cutters derived from easily machinable materials are not merely confined to increased productivity, but can have a very considerable effect on reducing overheads in such departments as tool room,

cutter grinding, etc. Good machinability also enables simplification of processes. Raw material cost and batch size must be allowed for, and consistency of machinability is essential. It is recommended that efforts be made by steel manufacturers to keep machinability consistent within reasonable limits. The psychological effect upon the operatives of introducing freely machinable materials is worth consideration.

Experience With Carbide-Tipped Tools, by M. E. Feldstein. (*Mechanical Engineering, April,* 1946, *Vol.* 68, *No.* 4, *p.* 307, 16 *figs.*)

It was decided to attempt a solution to the problem of getting more production per machine-hour, by studying all aspects of carbide-tool application, doing the job logically, systematically, and practically. The approach was resolved into such brackets as (1) tool engineering, (2) tool follow-up and processing, (3) tool manufacture, (4) tool maintenance. In the process of manufacturing cutting tools, practically all of the last issue of tools were made with cast Meehanite shanks, and a brief account of the manufacture of these is given. After a tool design was developed a standard sheet was drawn up containing all the data pertinent to its application. This drawing was issued by the tool-engineering division to the tool-making department, to the tool-maintenance department, and to the general foreman of the department in which the tool was to be used. When tools were returned for regrinding, they were reground to the original drawing. No grinding wheels were allowed on the job. Improper grinding methods produce weaknesses in carbide tips. After all finished cutting faces are ground, a hand-lapping operation is added.

Before and after grinding, carbide-cutting tools are given the Zyglo magnaflux treatment to detect whether any carbides require replacement because of cracks which may have formed in brazing or in grinding. The greatest mistake made by users of carbide-tipped tools is a tendency to think of them in terms of high-speed tool bits. This immediately leads into the trap of making tools with shanks which are too small. The next pitfall is failure to make toolholders rigid enough, with the result that tool life will be decreased tremendously, the type of finish will be unsatisfactory, and size will not be held.

The essentials of good milling with carbide-tipped cutters are fundamentally the same as the essentials of good milling with high-speed steel cutters, omitting the use of the proper coolant which is not desirable in carbide-milling: (1) Machine must be in good condition. (2) The work-holding fixture must hold the work rigid and must be securely fastened to table. (3) The correct cutters must be selected for the job. (4) Proper feeds and speeds should be selected and used. Although the items mentioned are essential for both conventional and carbide-milling, they are far more exacting when milling with carbide. Quite often the existing milling machine requires the use of a flywheel to aid in getting a smooth flow of power to the cutter. By mounting a round wire brush on a spindle so that the rotation of the cutter revolves the brush across the face of the teeth, it has been found possible to wipe the chips free of the carbides, doing a better, cleaner, and cheaper job than air. By adhering to the essential fundamentals of good milling practice, carbide-milling can be done on practically any machine in good condition, providing the power of the machine is not exceeded.

The following considerations always enter into the design of cutters: (1) Material to be milled. (2) Shape of the part to be milled. (3) Width and depth of cut, material to be milled, and horse-power of mill. (4) The cutter from the construction-service viewpoint. Carbides are set in at 5° negative radial rake and ground to 10° negative radial rake. By setting the teeth in as stated, we save grinding time on the face of the teeth. Radial rake protects the cutting edge and has much to do with the life of the cutter and should be determined from the material and the nature of the cut. Axial rake protects both the cutting edge and the point of the tooth, but not to the same degree as the negative radial rake. The material, the nature of the cut, and the depth of cut

should control the axial rake angle. The correct cutting speed for the material to be milled heads the list.

Charts showing recommended cutting speeds for various materials have been published by the Cincinnati Milling Machine Company. The rate of feed should be determined by the number of teeth in the cutter and the revolutions per min. of the spindle. For carbide-milling, hydraulic feed is ideal. A very definite advantage of hydraulic feed is the flexibility of the feed. If basic fundamentals are carefully analyzed and the system of tool controls, as described, is adhered to, the problem of tool application can be solved.

Rounding Effect in Centreless Grinding, by Albert H. Dall. (*Mechanical Engineering, April,* 1946, *Vol.* 68, *No.* 4, *p.* 325, 14 *figs.*)

The centreless grinder produces " round " parts within very small tolerances. If the work centre is placed on a line joining the centres of the wheels and a flat blade is used for support, it would seem that the piece would be ground to a constant diameter. Although this is true, it is unfortunate that many geometric shapes have constant diameter other than the circle. Since the centreless method shows a tendency to produce three-sided figures, it is significant to investigate what happens when a three-sided constant-diameter piece is submitted to the centreless process. When the work is placed above centre using a 30° angular top blade, the improvement in roundness is marked. The geometric relations of the blade, regulating wheel, and grinding wheel have a profound effect on the rounding of the workpiece.

The question may arise, why not place the work high above the centre and use a high-angle blade at all times ? If light cuts are taken with a sharp wheel, these extreme conditions can sometimes be used. Under ordinary production conditions, however, the forces increase as the wheel becomes dull. The high angle on the blade forms a wedge with the regulating wheel which may cause the work to jump upward. The work may jump so violently as to leave the machine. Most important factor is that of centre shift. Wheel interference is effective only in diminishing the errors when the errors are large. Other problems in rounding are often encountered in centreless grinding. One of these problems is that of so-called " chatter ". Structural rigidity with correspondingly high natural frequency prevents self-induced vibrations.

Other conditions of the setup than blade angle and height above centre must be taken into consideration for precision grinding : (1) on through-feed grinding, the guides for the pieces entering and leaving the wheels must be properly adjusted for both position and parallelism. (2) on long pieces, the portion extending from the wheels should be prevented from whipping by using proper fixtures. (3) in through-feed grinding, the tilted regulating wheel must be trued so that it contacts the work throughout its length. The centreless-grinding method is capable of producing round parts well within the limits of parts produced by the centre-type method.

Friction Cutting. (*Aircraft Production, May,* 1946, *Vol. VIII, No.* 91, *p.* 244, 13 *figs.*)

This article contains a quantity of data based upon the experience of several companies, but mainly upon experimental investigation carried out by the DoAll Company. Although there are discrepancies, it would appear that the process has applications, particularly in relation to the cutting of steels, which might well repay careful investigation under properly observed and controlled conditions. The cut is effected by a bandsaw, but the process differs from the normal process in that the saw is actually used not to cut the material, but to generate friction. The process of cutting is to melt the metal in the kerf, from which it is moved by the high-velocity blade, while the spaces between the teeth carry oxygen into the cut to increase the burning action.

The speed of the blade is a primary factor in preventing conduction losses.

Losses caused by radiation and convection are negligible. The hardening of the material at the edges of the cut should not exceed a depth of 0·002 in. Glass can be cut without being cracked, but there is a good deal of chipping at the edges. Carbide tool tips can be cut quite easily if well backed up, but Stellite cannot. Wood burns rather easily unless it is resin (synthetic) impregnated. Cutting is characterized by a very small, almost negligible, amount of downdrag and the fact that an oblique cut can very easily be made from almost any angle from 90° to zero in the one direction or to 135° in the other. For most steels up to ¼ in. in thickness a saw speed of 10,000 ft./min. is sufficiently high, and for material up to 14 S.W.G. in thickness a speed of 3,000 to 6,000 ft./min. usually gives satisfactory results. Thick sections up to 2 or 3 in. can be cut quickly and efficiently by rocking or tipping the material to start the cut. Friction cutting has been successfully adapted for the automatic cutting of profiles in sheet material. Friction cutting can be used extensively for cutting tubing. Most alloy steels are within the low-melting-point range and are, therefore, suitable for the friction-sawing process. Friction cutting of irregularly shaped ferrous materials is far more efficient than any other process. The DoAll Company states that the percentage of plastic materials suitable for friction cutting is very small.

An interesting application of friction cutting is for the salvage of tools and materials. The results of a number of tests made in the DoAll laboratories are summarized. An interesting point in General Motors' practice is the supercharging of the cut by directing a jet of compressed air upon it. It is the experience of General Motors that friction cutting causes a slight burr to be thrown upon both sides of the workpiece and in some cases the time required for the removal of burrs is consequently increased, although the operation can usually be done with a buffing wheel. Also, this firm has found that the hardness of the cut edge may be increased to a depth of approximately 0·005 in. and they therefore make a practice of annealing friction-cut pieces before final profile machining, in order to obtain as long a life as possible for the milling cutter. They recommend that before a new saw is used on production work, a few cuts should be made through an old file to dull the teeth. A blade life of approximately 40 hours is obtained.

On the Art of Cutting Metals, by Orlan W. Boston. (*Mechanical Engineering, April,* 1946, *Vol.* 68, *No.* 4, *p.* 302.)

A review of the developments in metal cutting, drawing attention to the need for further co-ordinated research.

Milling Hard Welded Steel, by F. Lucht. (*Materials and Methods, February,* 1946, *Vol.* 23, *p.* 482.)

Special arrangement for milling hard welded steel using a Carboloy cemented carbide tipped staggered tooth cutter.

(*Communicated by Industrial Diamond Review.*)

SURFACE, SURFACE TREATMENT.

Measurement of Surface Roughness, by C. J. Posey. (*Mechanical Engineering, April,* 1946, *Vol.* 68, *No.* 4, *p.* 305, 7 *figs.*)

It is possible to construct equipment that will measure and even record the linear deviations of the profile of a surface, along a selected path, from that desired. The difficulty lies in deciding what is to be done with this record. British practice favours using the arithmetic-average height, and can be used quite satisfactorily in comparing surfaces of similar materials produced by similar finishing methods. The identicalness of rough surfaces does not require

perfect geometrical similarity in the Euclidean sense, but rather a sort of statistical similarity. The statistical similarity can be measured by the method described herein.

Protective and Decorative Finishes, by R. E. Blakey. (*Machinery Lloyd, 22nd June,* 1946, *Vol. XVIII, No.* 13, *p.* 67, 5 *figs.*)

Part 1. Protective chemical methods and pretreatment of metals. Treatments of the simple immersion type for iron, steel, copper, copper alloys, aluminium alloys, zinc-base alloys, and magnesium alloys are described. Electro-deposited coatings and sources of corrosion troubles are dealt with.

WELFARE, SAFETY, ACCIDENTS.

Ten Maxims for the Prevention of Grinding Accidents. (*Industrial Diamond Review, May,* 1946, *Vol.* 6, *No.* 66, *p.* 135, 12 *figs.*)

This article offers advice to the users of grinding wheels, for the prevention of accidents and uneconomic use of equipment.

INDEX TO ADVERTISEMENTS

As a war-time measure the advertisement section of this Journal is now published in two editions, A and B. Advertisers' announcements only appear in one edition each month, advertisements in edition A alternating with those in edition B the following month. This Index gives the page number and edition in which the advertisements appear for the current month.

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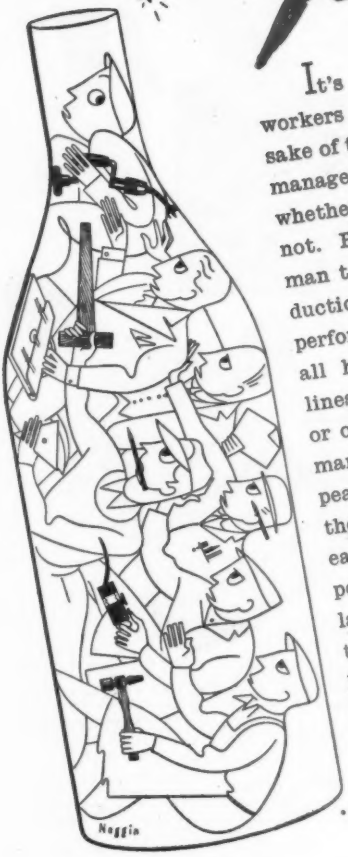

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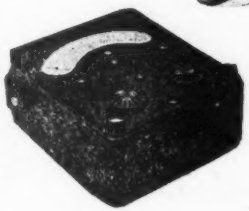

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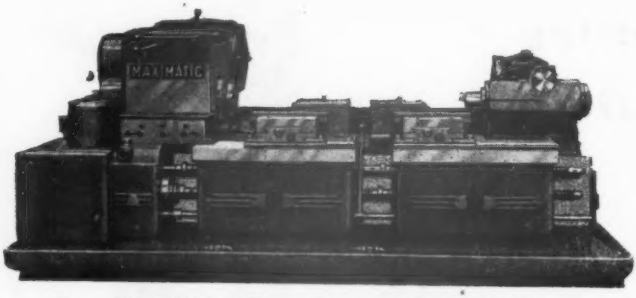

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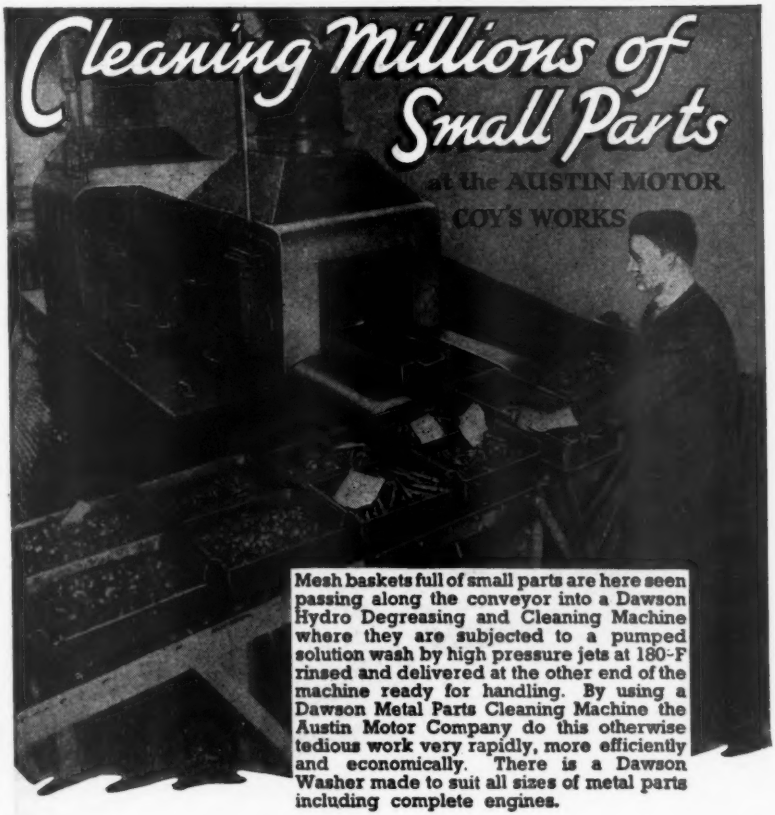

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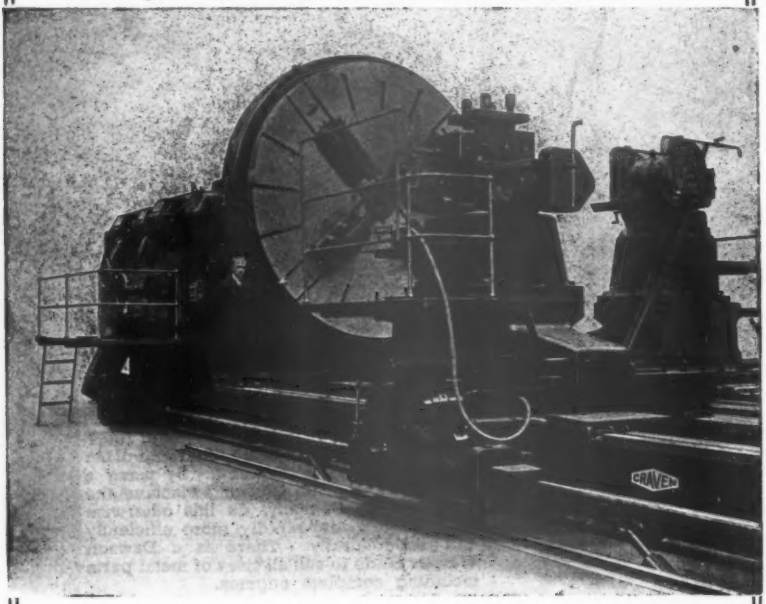

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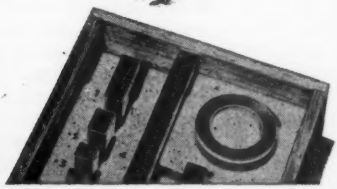

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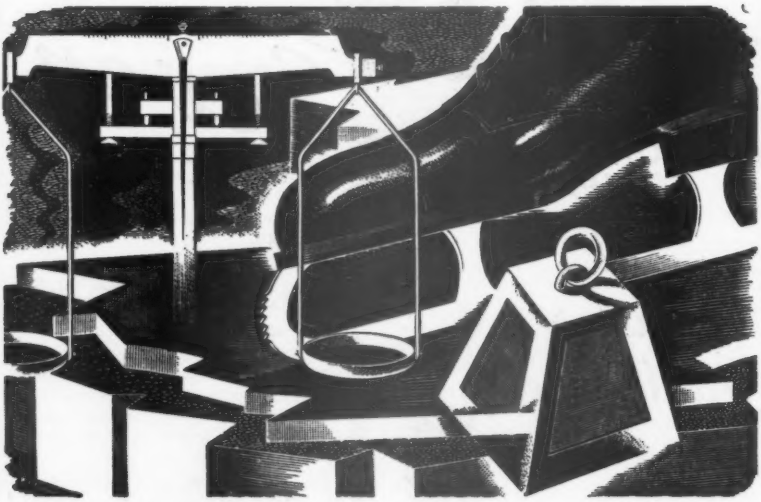

Thin—but strong

Skating on thin ice is not dangerous so long as the ice is hard enough and strong enough to bear the skater's weight. Three inches will bear him just as well as twenty-three and any increase in thickness is of no advantage to him. This truism is applicable to many things which have to stand strain or stress, including pressure die castings. But in pressure die castings thinness is a positive advantage, for thin sections are proportionately stronger than thick ones. Further, thin sections save metal and increase speed of production. So long, therefore, as strength and stiffness are adequate for the designer's purpose, the thinner the section the better the casting. And that is one more reason why Mazak Zinc Alloy is supreme for pressure die casting. For Zinc Alloy can be cast in thinner sections than any other alloy and Mazak possesses not only this facility but also the tensile strength and hardness which are imperative if the production of very thin sections is not to be regarded as skating on ice which is too thin for safety.

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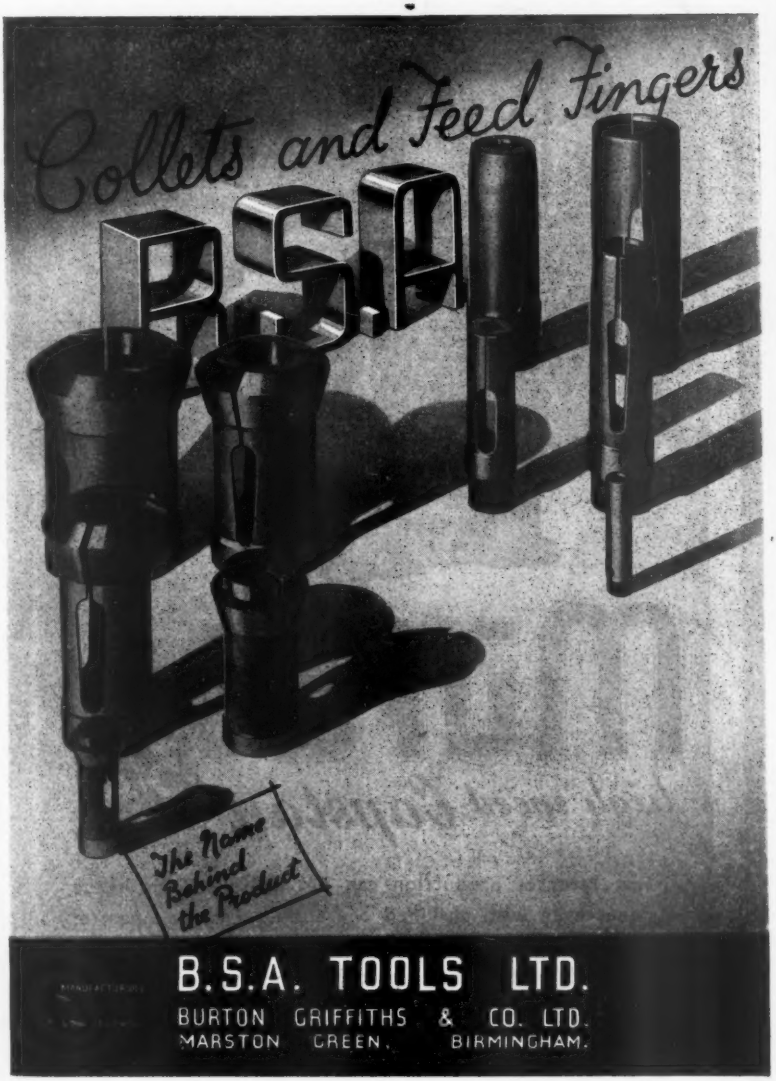
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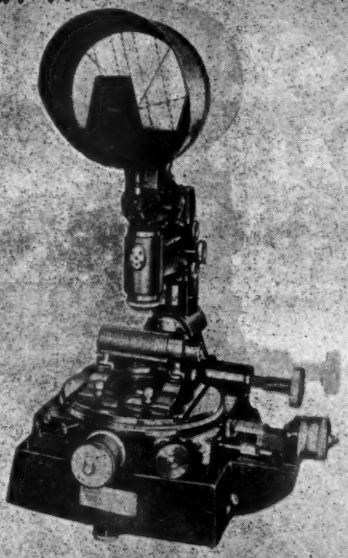

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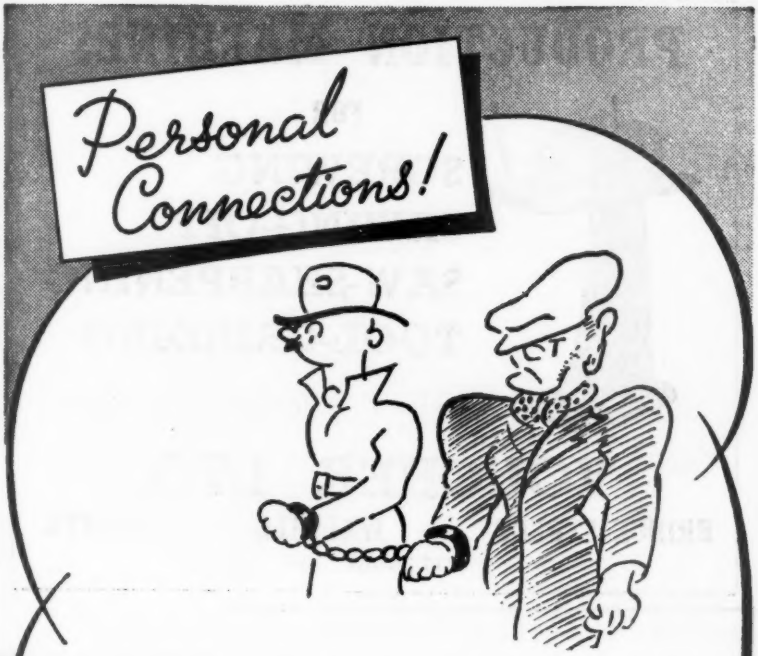

This illustration is to attract your attention. Our relationship with customers is of a much happier turn of mind than the 'connection' shown above. Nevertheless a close bond between ourselves and our customers does exist. An attachment, not of iron or steel, but of sincere friendship... mutual understanding which has grown and multiplied until we have 'personal connections' all over the world.

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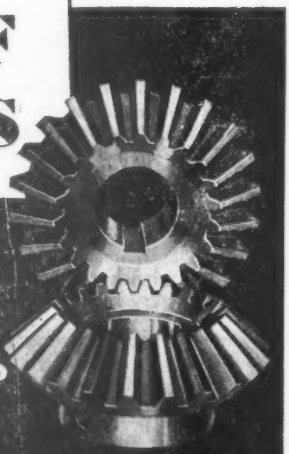

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AC DIRECT SWITCHING CONTACTOR STARTERS

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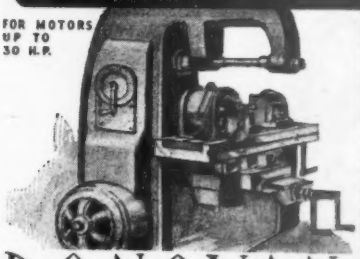

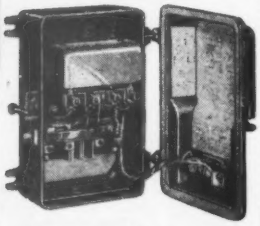

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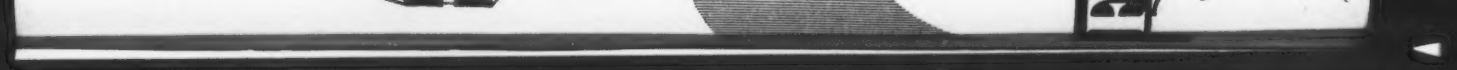

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